Pest Management Alliance Project Final Report
March 1, 2002 – February 28, 2003

Southern San Joaquin Valley
Citrus Pest Management Alliance

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EXECUTIVE SUMMARY

During second year of the Southern San Joaquin Valley Citrus Pest Management Alliance Program, the participants met on a monthly basis and insect and mite sampling was initiated on March 1, 2002 and ended on December 1, 2002 in 10 Kern County and 10 Tulare County citrus orchards. During this year, the majority of treatments in the Kern region were for citrus thrips, katydids, and glassy-winged sharpshooter. An average of 2.7 pesticides were applied per orchard and 3 of 10 orchards received *Aphytis* wasp releases for red scale in this region. Glassy-winged sharpshooter (GWSS) preharvest disinfestation methomyl (Lannate) treatments applied in fall of 2001 significantly reduced predatory mite populations the following year. GWSS Admire treatments reduced the need for California red scale and citricola scale treatments. The majority of treatments in the Tulare region were for citrus thrips, California red scale, citricola scale, worms, and katydids. Cottony cushion scale and citricola scale are emerging as sporadic but serious pests in this region. The new insecticides used for citrus thrips (Success) and California red scale (Esteem and Applaud) control, that replaced organophosphates, are not very effective in controlling this pest. An average of 2.5 pesticides were applied per orchard and 3 of 10 orchards received *Aphytis* wasp releases for red scale in the Tulare region. Packout grade was independent of insect/mite damage to the fruit and depended more upon time of harvest in relation to market price. Costs of treatments are under evaluation and growers will choose to reduce or alter pesticide use based on costs of treatments as well as their long-term perspective on pest resistance to pesticides. Weed plots within these orchards documented that growers can reduce herbicide but still maintain weeds below damaging levels by eliminating preemergent insecticide and/or by relocating irrigation emitters under the shaded canopy of the tree Herbicide run off was demonstrated to be reduced by the use of cover crop.

Body of Report

A. Introduction

If we are to increase adoption of IPM methods that decrease reliance on broad spectrum pesticides, we must demonstrate to the grower that program strategies are effective and economically viable. In this project, Cooperative Extension personnel have established citrus IPM demonstration areas in Tulare and Kern Counties (Kern was already established in the 2000 field season using Citrus Research Board funding). A group of 10 citrus orchards in each county have been identified that show a range of pest management methods. A portion of the growers utilize broad spectrum pesticides as their main line of defense. A second portion of the growers use *Aphytis* wasp releases for California red scale and carefully chosen selective pesticides for other pests. A third portion of the growers will use a combination of techniques including an occasional broad spectrum pesticide. Monitoring is conducted by UC personnel for California red scale, yellow scale, citricola scale, citrus red mite, citrus thrips, citrus cutworm, katydid, glassy-winged sharpshooter, cottony cushion scale, and citrus peelminer. Activity of predators and parasites is also monitored. The monitoring in Kern County is directed by Craig Kallsen and in Tulare County is directed by Neil O'Connell. This sampling does not replace that currently being conducted by the grower or their PCA (pest control advisor) but is done by UC technicians so that we can compare the consequences of various pest management strategies between orchards. The results of the technician samplings were reported to each cooperator. The results were reviewed at monthly informal meetings with the cooperators to provide an overview of pest/beneficial activity, monitoring procedures and treatments. O'Connell, Kallsen and Grafton-Cardwell held regular field days and maintained web pages describing the activities. At the end of the season, the fruit damage was rated and the pack-outs recorded for each orchard. The overall goal is to document the results of the various pest management strategies, assess the economics of the strategies, and train and involve growers and PCAs in biologically-based IPM strategies throughout the season.

Project objectives:

Objective 1: Creation and Coordination of Citrus Team

- Task 1.1 Create the Citrus Pest Management Alliance Team
- Task 1.2 Coordinate activities of the Alliance Team

Objective 2: Field Monitoring of Citrus Orchard Demonstration Sites

Field monitoring is done to evaluate the pest pressures in each of 10 orchards in Kern and Tulare Counties, record the response of the pests to the various management techniques, and evaluate the resulting damage to the fruit.

- Task 2.1 Monitor pests and beneficials in 20 demonstration orchards (10 each in Tulare and Kern counties)
- Task 2.2 Rear and Release Vedalia Beetles for control of Cottony Cushion Scale
- Task 2.3 Evaluate Pest Damage at the End of the Season
- Task 2.4 Identify research projects to address emerging pest problems

Objective 3: Evaluate the Efficacy of Various Weed Management Strategies to Reduce Herbicide Use.

Orchard floor management in Tulare County citrus by means of premergent and postemergent herbicides has been a standard practice for many years. Weed species compete with the trees for nutrients and moisture, and with dense vegetation on the orchard floor during the winter there is the perception of increased risk of frost damage to crop and trees. Increasing concerns regarding water quality have focused attention on cultural practices that might be involved in water quality issues. Among these practices is the use of herbicides for weed management. One concern has been the potential for offsite movement of an herbicide and the possibility of contamination of groundwater. Any practice that might mitigate the potential for offsite movement would reduce the possibility for water quality degradation. Recent research has addressed the issue of potential runoff of premergent herbicide applications and these mitigating measures will be demonstrated in this project.

Task 3.1 Demonstrate the efficacy of reduced herbicide use in row middles
Task 3.2 Demonstration of reduced weed germination through relocation of emitters
Task 3.3 Demonstration of reduced numbers of herbicide applications

Objective 4: Economic Evaluation of Pest Management Practices

Citrus growers need to see that the economics of biologically-based pest management are comparable if not better than traditional management techniques that depend solely on broad spectrum pesticides.

Task 4.1 Evaluate the economics of various citrus pest management tactics

Objective 5: Project Outreach and Extension

Using various organizations and methods, information will be provided to citrus growers on the insect population densities, the effects of the pest management practices, new thresholds, and control tactics that are discovered, and the economics of each pest management strategy. The organizations will include UC Extension, the Citrus Research Board, CCQC, CAPCA, and Sunkist. The methods of information dissemination will be web pages, Citrograph and Subtropical Fruit news, faxes, newsletters, brochures, field days, slide shows, and training workshops.

Task 5.1 Field Days and Workshops
Task 5.2 Publications
Task 5.3 Web Pages

B. Results

Objective 1 and Task 1:

Development and Coordination of the southern San Joaquin Valley citrus PMA team: The primary team members (Neil O'Connell, Craig Kallsen, and Beth Grafton-Cardwell) met with the alliance participants monthly and conducted two field days. A yearly citrus IPM workgroup meeting is held in which this project is discussed.

Objective 2 and Task 2: Monitoring insect pests and natural enemies, releasing vedalia beetles, and assessing the fruit damage pests cause in the citrus IPM demonstration sites

A. Prelimary project results.

Kern Region:

Early season Pests. The year 2002 was a fairly severe citrus thrips year throughout the valley. Generally, Success was the selective insecticide of choice (Table 1). However, if the grower was concerned about katydids or GWSS, they respond by using Baythroid or Danitol (pyrethroid) as their citrus thrips treatment in order to kill two pests with one insecticide treatment. Alternatively, they tank-mixed a low rate of a pyrethroid (Baythroid) or organophosphate (Dimethoate or Lorsban) with the Success to kill the katydids or GWSS. The tank mix choice is effective for several reasons. A number of citrus thrips in Kern County have developed resistance to pyrethroids and so Success is more effective. But Success does not control large katydids or GWSS, thus a low rate of the pyrethroids or OPs controls these pests. Natural enemies are not severely reduced by low rates (1/2 the label) and so survive to assist with control of citrus thrips and other pests.

Pyrethroids (Baythroid or Danitol) and carbamates (Lannate and Carzol) are broad spectrum and, used for citrus thrips or GWSS at labeled rates, they have the effect of severely reducing predatory mites (Figure 1, Orchards 1, 9, and 10). If the rate of OP (Lorsban, Dimethoate) or pyrethroid was reduced then the impact on the predatory mites was less severe or relatively nontoxic (Orchards 5, 6, 7, 8). This was done as a tank mis to kill katydid, which are very sensitive to pyrethroids and OPs or GWSS which are very sensitive to pyrethroids in combination with Success for citrus thrips. Thus, broad spectrum pesticides can be used selectively by reducing the rate to a level that natural enemies will survive. Kryocide is the preferred katydid treatments in the biologically-based program and was applied in orchard 4. Orchard 1 applied Lannate for glassy-winged sharpshooter control in the early season, eliminating predacious mites and citrus thrips.

A healthy predatory mite population, that assists with citrus thrips control is > 1 per leaf. Table 2 shows the treatments applied for citrus thrips and katydid, the resulting thrips damage, and the occurrence of fall Lannate treatments for preharvest disinfestations of fruit of GWSS and the in season Admire treatments for GWSS reduction. Figure 1 shows the levels of predacious mites during 2002. There was a trend in the orchards where Lannate was used in fall of 2000 or 2001 (Table 2) for the predatory mite densities to be reduced in the subsequent spring (Orchards 1, 2, 3, 8, and 9). Thus, Lannate is having a long-lasting and significant impact on predatory mites needed for both citrus thrips control and citrus red mite control. The result is that when the selective insecticides Success or Veratran are applied in April-May for citrus thrips, there are very few (<0.5/leaf) predacious mites available to assist with thrips control because of the Lannate treatments applied the previous fall. Since Success and Veratran have a fairly short residual effectiveness, multiple applications may be needed to control citrus thrips. This increases costs to the grower and if the grower uses the same insecticide, increases the rate of resistance development in thrips. There was no such trend for the Admire treated orchards. Thus, Admire does not have a long-term effect on predatory mite densities.

Generally, the treatment threshold for citrus trips is 5% fruit infested with immature thrips if predacious mites < 0.5/leaf and 10% infested fruit if predacious mites are > 0.5/leaf. At petal fall, orchards 3, 4, 5, 6, 7, 8, and 9 had higher than threshold densities of thrips at petal fall and treatments were warranted. Most treatments (exceptions orchards 3 & 8) were successful in quickly reducing thrips. Growers in orchards 3, 5 & 6 applied additional treatments for thrips. Growers on the broad spectrum calendar type spray program tend to spray as soon as petal fall occurs. Sometimes the densities of citrus thrips do not warrant treatment. Growers who use biologically-based IPM can often eliminate a thrips treatment if they are monitoring their orchard very carefully and have good densities of predacious mites.

An average of 1.4 pesticide sprays were applied to each orchard in the Kern County area for early season pests (mites, thrips, katydids) in both 2001 and 2002 (Table 1).

Scale Pests. One orchard was treated with Esteem and one orchard with Applaud to control California red scale and 3 orchards released *Aphytis* wasps (Table 1). Fruit in the Kern region matures earlier (October) than the Tulare region. Growers consider *Aphytis* releases a high risk because the parasites often don't clean up the scale on the fruit in time for harvest, however, there are still a number of growers that use biological control as the basis for their scale management program. The number of scale insecticide treatments was reduced from 0.4 in 2001 to 0.2 in 2002 because the Admire treatments for GWSS have moderate efficacy against California red scale. Table 3 shows that the percentage parasitism of California red scale in October 2002 was quite a bit lower than the percentage parasitism in 2001. These data suggest that the Admire treatments may be having a negative effect on Aphytis.

One of the results of reducing organophosphate use for California red scale, has been an increase in citricola scale which was very easily killed by this group of insecticides in the past. Initially, it was the IPM orchards (Aphytis release) that suffered with in increase in citricola scale problems because they stopped using organophosphates to preserve natural enemies. Now it is a problem for most growers because they have switched from OPs to insect growth regulators (Esteem and Applaud) and IGRs do not work very well on citricola scale. IGRs affect molting and citricola scale only molts twice a year. Citricola scale is difficult to control biologically because it has only one generation per year and the natural enemies prefer the larger instars which are only present for a few months of the year. Citricola scale is reduced fairly well by Admire treatments and so the problems with have diminished in orchards 2 and 3 from the previous season. Of concern, is the presence of low amounts of citricola scale in most orchards (Table 4). Admire is only providing partial control of this pest, and when these treatments stop this pest is likely to increase quickly. Lorsban is still the most effective treatment for citricola scale and if applied at a rate of 6-12 pints/acre, it reduces citricola scale so low that treatments are not needed for 2-3 years. The neonicotinoids (Admire, Provado, Assail) have efficacy against this scale, but treatments are more likely to be yearly.

A average of 0.5 and 0.2 treatments per orchard were applied for scale pests in the Kern region (Table 1) in 2001 and 2002. The reduction in treatments is likely due to the Admire treatments applied for GWSS.

Glassy-winged sharpshooter. During 2002, all growers were asked to treat with Admire for glassy-winged sharpshooter (GWSS). This had the effect of greatly reducing GWSS densities throughout the region (Fig. 2). In addition, orchard 1 applied Lannate in-season and orchard 4 applied Evergreen in-season. Thus, there were a total of 1.2 treatments for GWSS. The effect of the Lannate treatment was to eliminate all natural enemies. Evergreen has little or no effect on natural enemies because it is extremely short-lived. Because of the area-wide use of Admire, late-season Lannate treatments were not needed in these orchards to disinfest fruit prior to harvest. This is good for biological control, since we noted above that the predatory mites are reduced the following spring by these late season Lannate treatments. Glassy-winged sharpshooter has greatly increased the number of broad spectrum insecticide applications (+1.1/orchard) in the Kern County region (Table 1) and this is likely to cause problems with other pests eventually because of the loss of natural enemies.

Fruit Damage

Fruit scarring damage of the fruit was rated in the bins at harvest. Fig. 3 shows that in the 2000-01 harvests, Kern County orchards had low levels of thrips, katydid and worm damage. Most of the red scale infestation is cleaned up by the high pressure washer in the packing house. Thus, damage to the rind of fruit due to insects was less than 7% of total fruit no matter what pest management program was followed. In the 2002-03 harvest (which is not quite completed) the amount of mechanical damage (abrasion due to high winds) was very high (20-25% of the fruit) and accounted for more scarring than all insect damage combined. Citrus thrips damage was fairly heavy in orchard 3 (15-20%), but the % of fruit packed to fancy grade (Table 1) was not very different from other orchards. These data suggest that thrips treatments could be lessened for orchards that can be marketed when prices are high (early season).

Tulare Region:

Early Season Pests. The year 2002 was a more severe citrus thrips year than 2001, but somewhat fewer katydids were present. Prior to petal fall, katydids only damage leaves and so are of little concern. However, at petal fall, they prefer the young fruit and must be controlled. In 2002, the majority of katydids emerged prior to petal fall and so the remainder were fairly easily controlled with citrus thrips treatments of Success, Lorsban, Baythroid, or Danitol. In the previous year, katydid populations were very heavy post petal fall and growers applied more Lorsban to control the populations. Pyrethroids (Danitol and Baythroid) are fairly broad spectrum and have the effect of reducing natural enemies needed for other pests. Low rates of Lorsban are selective because many of the natural enemies have developed resistance to this insecticide. Reduced risk insecticides such as Success and kryocide can only kill young katydid instars and so in some years these insecticides are effective and other years they are not (when the hatch of katydids is prolonged).

Table 5 shows that six orchards in the Tulare region used selective insecticides (Success or Agri-Mek) as their first thrips treatment. Four orchards used broad spectrum insecticides (Baythroid or Danitol) as their first citrus thrips treatment. Two orchards mixed Lorsban or Cygon in with the thrips treatment to control katydids. Figure 4 shows that the insecticides were generally very effective in reducing citrus thrips to less than 5%

fruit infested (Orchards 1, 2, 5, 6, 8, 9). Several orchards treated before citrus thrips were detected (Orchards 3 and 8). Two orchards treated with pyrethroids (Orchards 4and 7) and say an increase in citrus thrips following the treatment suggesting that the thrips have developed resistance to pyrethroids. These orchards required a second treatment of Success or Dimethoate to reduce the thrips populations. Predatory mites were extremely low in all orchards except Orchards 9 and 10.

Worms (Table 6) were treated for in four locations using Kryocide or Dipel. These insecticides work well to reduce the overall numbers of worms if the weather is warm and the instars of worms are young. These insecticides are very selective, relatively inexpensive, and allow natural enemies to survive. After petal fall, if worms are still present, growers use broad spectrum insecticides for citrus thrips. During 2002, the cutworms had pupated by the time that petal fall occurred (first week of May) and broad spectrum insecticides were not needed for worm control.

An average of 1.1 and 1.7 early season sprays were applied in Tulare County orchards during 2001 and 2002 (Table 4). The increase was primarily due to higher thrips and worm densities in 2002.

Scale Pests. Four orchards were sprayed with Esteem, one orchard was treated with Applaud, and three growers released *Aphytis* wasps for red scale control (Table 4). California red scale densities were relatively low in all orchards and in the Aphytis release orchards the scale was well controlled by parasites (*Aphytis* and *Comperiella*) this year (Table 7).

Similar to the situation in Kern County, Tulare County growers are experiencing increasing problems with citricola scale as they eliminate organophosphate treatments and depend on insect growth regulators (Esteem and Applaud) for red scale and Success for citrus thrips. Citricola scale was present in 4 orchards in 2001 and 8 orchards in 2002 (Table 8). It required treatments of Lorsban in 2 orchards (Orchards 2 and 10). The grower in orchard 2 waited to treat until October in order to allow the natural enemies of California red scale to survive. Grower 10 applied two treatments of low rates of Lorsban in May and August. The early treatment was designed to reduce honey dew and sooty mold prior to harvest. The second treatment was more effective in controlling the pest because the population consists of small nymphs on the outside leaves of the tree in August. Lorsban continues to be the most effective treatment for citricola scale.

Of even greater concern in the Tulare County Region, is the increase in the presence of cottony cushion scale (Table 9). Cottony cushion scale has become an increasing problem in San Joaquin Valley orchards due to the use of new insecticides (Esteem, Applaud, Admire, Provado, Assail, Danitol, and Baythroid) that are highly toxic to the predatory vedalia beetle. Vedalia beetle is quite resistant to organophosphate insecticides. As grower shift from organophosphates to the new insecticides, vedalia is removed, and these insecticides work poorly on cottony cushion scale, releasing it from control. In 2001, four orchards had cottony cushion scale and two of those had damaging levels. Vedalia appeared in May and adequately controlled orchard 1, but the grower treated orchard 5 with Supracide to eliminate CCS in orchard 5. In 2002, nine orchards had cottony cushion scale and 3 had damaging levels in the spring. Vedalia reduced the CCS in orchards 3 and 7 but was less effective in orchard 1. Many orchards in the fall of 2002 had low levels that may become problematic in 2003 depending on when vedalia

beetle arrives. This situation is likely to be exacerbated by GWSS treatments when that pest arrives in this region.

An average of 0.6 and 0.7 treatments per orchard were applied for scale pests in the Kern region in 2002 (Table 5).

Fruit Damage.

Fruit scarring damage of the fruit was rated in the bins at harvest. Fig. 5 shows that in the 2000-01 harvests, Tulare orchards had 5-15% mechanical damage of fruit (machinery, wind, hail). All orchards had low levels of damage due to katydid and worms. The high pressure washer in the packing house cleans up most of the red scale infestation. Thus, damage to the rind of fruit due to insects was less than 7% of total fruit no matter what pest management program was followed. In the 2002-03 harvest (which has a number of unfinished orchards) the amount damage due to insects is very low. Orchards experienced similar damage (with the exception of California red scale) no matter what treatment regime was followed. Packouts (Table 5) depended more on market conditions and time of harvest then insect damage. These data suggest that some insecticide treatments may not be warranted.

Objective 3 and Task 3. Evaluation of the effects of one of four methods to reduced herbicide use in 8 of the Tulare County citrus orchards. Evaluation of herbicide use, weed suppression, and the potential for mitigation of offsite movement of herbicides was examined for four orchard floor management practices in citrus. These practices include: application of a preemergent herbicide in the fall, spring or both; no preemergent herbicide application with only the use of postemergent herbicides; relocation of the irrigation emitter under the tree canopy to eliminate irrigation in the sunlight area outside of the canopies where weed seed is present; use of a cover crop to minimize runoff of winter rains from the orchard floor and possible associated preemergent herbicide.

A. Preliminary Results:

Task 3.1 Use of a cover crop to mitigate offsite movement of herbicide. A cover crop was planted in November 2001 between the rows of one orchard. One cover of clovers, vetch, and brome was planted over 100% of the area in the middle between rows. Another cover was a mixture of oats, barley, and triticale and vetch and was planted to 20% of the middle. Treatment one (T1) was four adjacent rows with 100% of the middles planted. The second treatment (T2) was four rows, 20% strips alternating with 100%(T2-20%) and 100% alternating with 20% strips (T2-100%). The third treatment (T3) was not planted to a cover crop. Each treatment was five rows and four middles wide and was replicated four times. Simazine preemergent herbicide was applied November 16 to the orchard. No herbicide was applied to T1,2,3. Catch basins were installed to capture runoff of rainfall from each treatment.

Measurements: herbicide concentration on the soil surface was measured following the application of the fall herbicide spray. Samples of rainfall runoff were collected from both cover crop treatments as well as the area free of cover crop. Samples were sent to the department of pesticide regulation for analysis for the presence of herbicide and concentration of materials present.

Results for three rainfall events were measured and demonstrated a reduction in volume of runoff water as well as a reduction in the concentration of simazine in runoff water for the cover treatments versus the non cover treatment (report submitted to Department of Pesticide Regulation June 2002-separate study funded by department of pesticide regulation).

Task 3.2 Reduced use of preemergent herbicide. Four of the cooperators use only postemergence herbicides for weed suppression. Glyphosate is applied three times to emerged weeds during the growing season.
Results: The presence of winter annual weeds was evaluated in February 2002 in each of the four orchards. Summer annual weeds were measured in June and August as well (Table 10). A site with both preemergent and postemergent sprays is included in the table as a comparison. Three of the four orchards in June and all four orchards in August that restricted herbicide use to post emergent herbicides had levels of weeds comparable or less than the orchard that used both pre and post emergent herbicides. This suggests that careful use of post emergent herbicides can help to reduce the need for pre emergent herbicides.

Task 3.3 Reduced weed germination by means of relocation of the irrigation emitter. Two growers currently under a preemergence herbicide program agreed to relocation of emitters from their position outside the tree canopy to a position under the canopy. The objective was to apply and maintain irrigation water in the shaded area under the canopy resulting in reduced weed growth outside the canopy.
Measurements: Emitters were relocated in two adjacent rows in each orchard this spring, with the emitters in the row on each side of these two rows remaining in the standard emitter location serving as the control/standard. In one orchard the standard is a fogger located at the northeast and southwest corners of the tree outside the canopy. Relocated emitters are two microjets positioned under the canopy. At the second site one microjet between two trees in the row is the standard. Relocation involves moving the emitter under the canopy.
Results: Weed measurements taken in June, but even more so in August, at the two sites (Tables 11 & 12) demonstrate that moving the emitters under the shaded canopy of the tree reduces weed densities outside of the tree.

Task 3.4 Comparison of weed growth with and without herbicide within the orchard. Three of the cooperators applied a premergence herbicide in the fall for winter weed suppression. Postemergent herbicide sprays are applied in the spring and summer for weeds escaping preemergent sprays. In two of these orchards when the fall preemergent spray was applied, the spray was omitted from the area between four rows on one end of the orchard. The remaining area of the orchard received the herbicide spray. The fall spray consisted of a combination of simazine and diuron, both preemergent herbicide materials.
Results: Evaluations of winter annual weeds were made in February and of summer annual weeds in June and August at both sites in the areas in each orchard with and without the fall herbicide spray (Table 13) indicate that a fall preemergent herbicide greatly reduces both winter and summer annuals. However, by August, one site did not show differences between areas with or without the fall 2001 premergent.

Objective 4 and Task 4. Economic analysis of the various pest management strategies. We had a grower meeting in Tulare County with the Extension Economist on the project (Eta

Takele) and developed a cost questionnaire that the growers are now completing. This questionnaire asks the grower for his costs for the pesticides, application of pesticide, water used to apply the pesticide, gasoline, *Aphytis* releases, and pest monitoring. We can not complete the cost analysis until we have at least two years of data. A number of treatments for scale insect pests are applied every 2-3 years and so a single years analysis is insufficient to draw conclusions. In addition, the 2002-2003 harvests are still in progress in the Tulare region. When we have the complete data set, we will analyze it and produce a paper on the subject.

Objective 5 and Task 5. Provide extensive outreach of the information gleaned from the demonstration orchards through newsletters, web pages, public meetings, TV, and radio.

1. Number of Cooperator meetings held (Meetings are roundtable discussions of current pest and natural enemy monitoring results):
    a. Kern County Alliance Participants: 8 meetings (January-December 2001) held at the UCCE Extension office in Bakersfield. An average of 8 participants.
    b. Tulare County Alliance Participants: 6 meetings (March-December) held at the Kearney Agricultural Center in Parlier. An average of 8 participants.
2. Field Days
    a. Kern County October 3, 2002. 60 participants. ½ day session in which citrus growers and pest control advisors were invited to come to a 1 hour presentation of the Kern IPM Demonstration program at the Kern County Extension Conference room. The slide show was followed by a roundtable discussion by producers of Aphytis wasps about how they are produced and the benefits for citrus IPM.
    b. Tulare County: October 4, 2002. 60 participants. ½ day session in which citrus growers and pest control advisors were invited to come a presentation by Neil O'Connell of the Tulare IPM Demonstration project at the Tulare Ag Center.
    c. Tulare County: October 9, 2002. 50 participants. ½ day field session in which Neil O'Connell discussed the results of his experiments to reduce herbicides through cover crop, moving emitters, and eliminating pre emergent treatments in several orchards. Beth Grafton-Cardwell discussed citricola scale life cycle, how to monitor for it and how to control it.
3. Publications
    a. Web site (www.uckac.edu/citrusent). The monitoring results for glassy-winged sharpshooter and parasites, citrus thrips, citrus red mite, predatory mites, California red scale and parasites, citricola scale and parasites, cottony cushion scale and vedalia beetles, citrus peelminer, katydids, and citrus cutworm are updated every week. The insecticide treatments are listed and the response of pests and beneficials to these insecticides are discussed.
    b. Grafton-Cardwell, B. 2000. IPM project begins in Kern County. Citrograph 85: 10-11.
    c. Plant Protection Quarterly article: Grafton-Cardwell, B., C. Reagan, C. Kallsen, and M. Bartels. Glassy-winged sharpshooter in San Joaquin Valley citrus. KAC Plant Prot Quart. 11(2): 4-7. This publication can be viewed on the website: http://www.uckac.edu/ppq/PDF/01April.pdf

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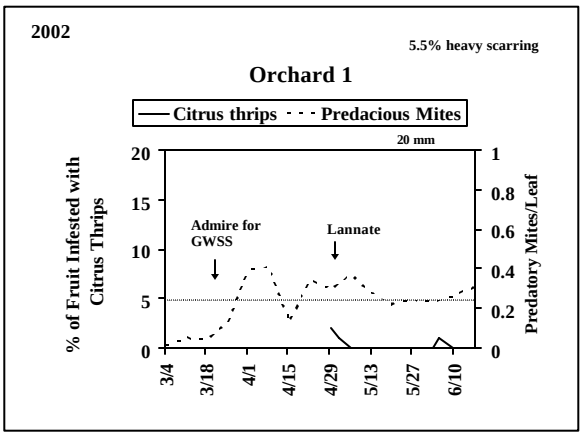
C. Summary and Conclusions.

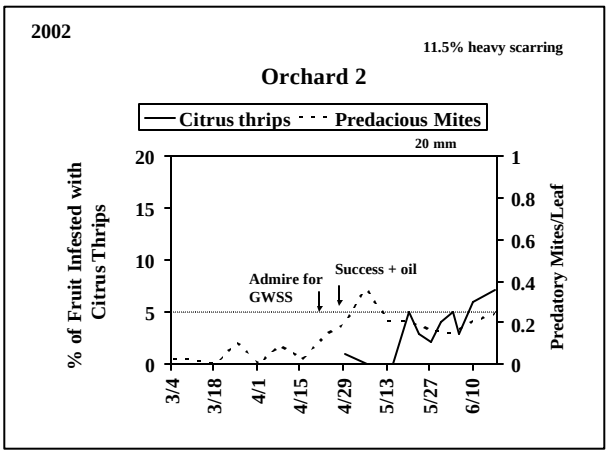
We have worked with 20 Pest Control Advisors and growers from Kern and Tulare counties on the effectiveness of various citrus pest control strategies on a monthly basis for two years. We have found that % fancy packout of citrus fruit depends more on time of year, packing house, and prevailing market than on insect and mite damage. That is, growers using a variety of pest management tactics have similar returns on their investment. Therefore, the incentive for the grower to use soft pesticides or to reduce pesticides will be to; 1) reduce costs of pesticides and applications, 2) improve worker safety, and 3) avoid development of pesticide resistance in pests. Generally the more a grower sprays, the more he spends and the costs for scale treatments are much higher than thrips, worms, or katydid because the speed of application is slower and the volume of water is higher. Kern and Tulare growers are applying on the average 1.8 to 2.4 insecticide treatments per year for all pests of citrus if GWSS is not present. This is a relatively low number of insecticides. If GWSS is present, the treatments increase by approximately 1 treatment per orchard. The pests which escalate insecticide use include citrus thrips, worms, katydids, citricola scale and cottony cushions scale. Worms and cottony cushions scale have fairly good biological control and so a program of soft pesticides for these pests is very effective. Thrips, katydids, and citricola scale do not have good biological control and so careful alternation of Success/Agri-Mek/Veratran for thrips and low rates of Lorsban for katydids and citricola keeps costs low, maintains natural enemies (avoiding secondary outbreaks), and reduces the rate of resistance development for thrips. Of concern is the trend for growers to treat in consecutive years with Success for thrips and Esteem for red scale. Eventually the pests will develop resistance. Also of concern is the toxicity to natural enemies of the majority of treatments for GWSS control (Lannate, Provado, Assail, Danitol, Baythroid, and Admire). In areas like Tulare County where cottony cushion scale is common, treatments for GWSS are likely to disrupt the existing IPM program and cause secondary outbreaks of various pests.

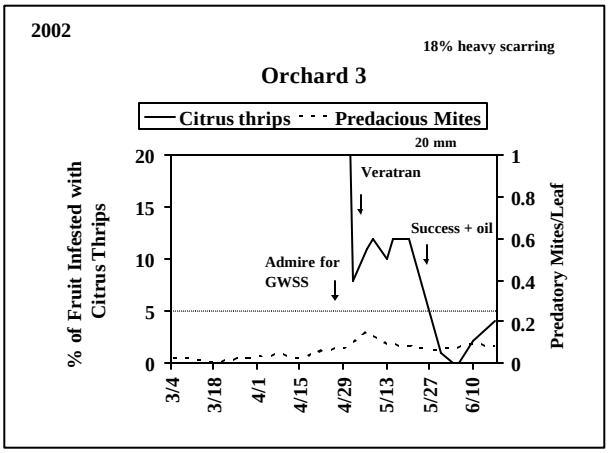
Several of the herbicide regimes tested in this project have potential for reducing herbicide use. Weed plots within these orchards demonstrated that growers can reduce herbicides but still maintain weeds below damaging levels by eliminating preemergent insecticides and/or by relocating irrigation emitters under the shaded canopy of the tree Herbicide run off was demonstrated to be reduced by the use of cover crop.

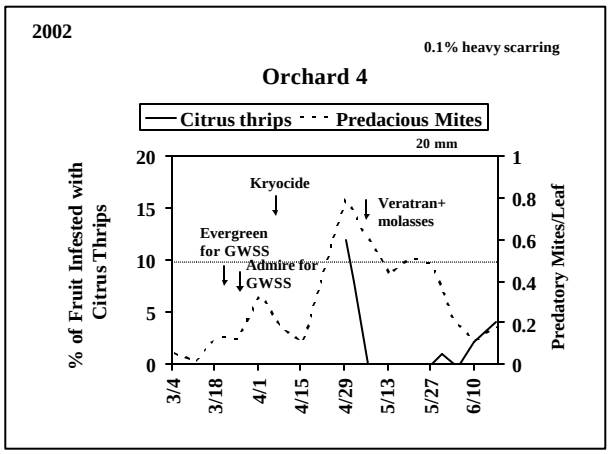
This project has provided a clear picture of the current pest pressures experienced by Tulare and Kern County citrus growers. The two regions vary in their pest problems. Kern growers struggle with citrus thrips and glassy-winged sharpshooters. Their scale pest problems are minimal for the moment because the Admire pesticide treatments for GWSS assist with citricola scale and red scale control. Tulare growers struggle more with worms, katydids, citricola scale and cottony cushion scale. When GWSS reaches this region, problems with cottony cushion scale may become severe. In both regions, there are a small number of insecticide treatments applied without regard to pest densities. The justification, is that not all acreage can be covered quickly enough with spray rigs. In general, however, growers are practicing a high level of sampling of citrus pests and responding to economic thresholds appropriately.

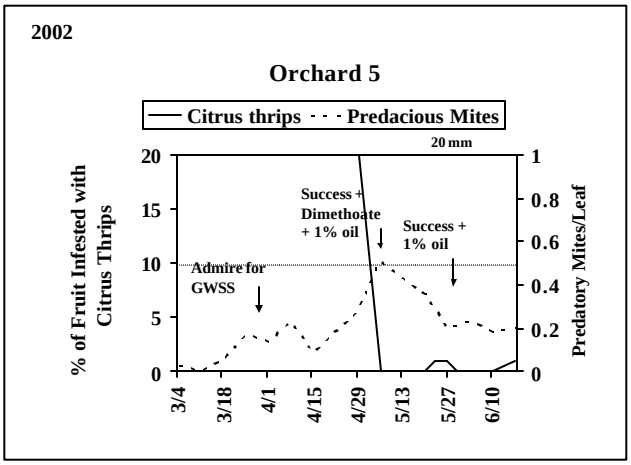
Figure 1. The impact of early season insecticide treatments for citrus thrips, katydid, and glassy-winged sharpshooter on pest densities and predacious mites in 2002 in Kern County.











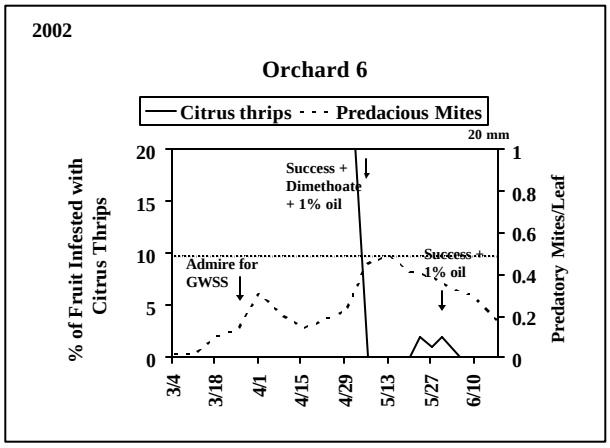
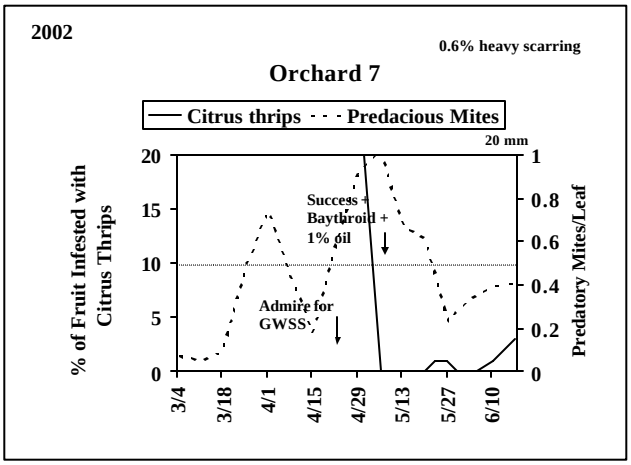
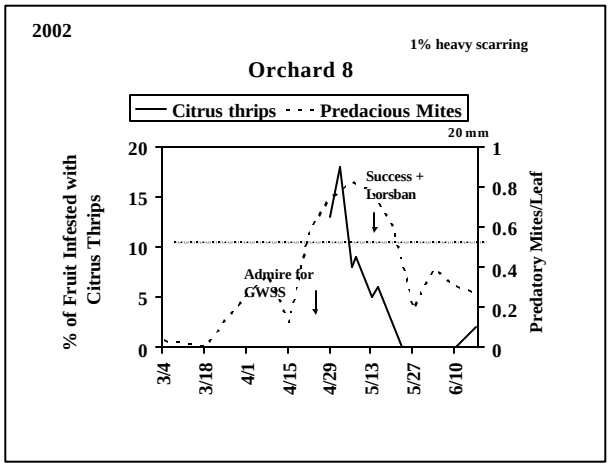
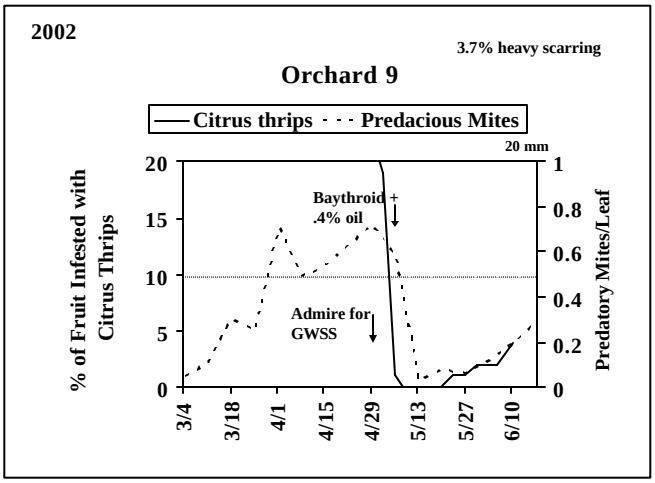


Figure 1 (continued). The impact of early season insecticide treatments for citrus thrips, katydid, and glassy-winged sharpshooter on pest densities and predacious mites in Kern County.







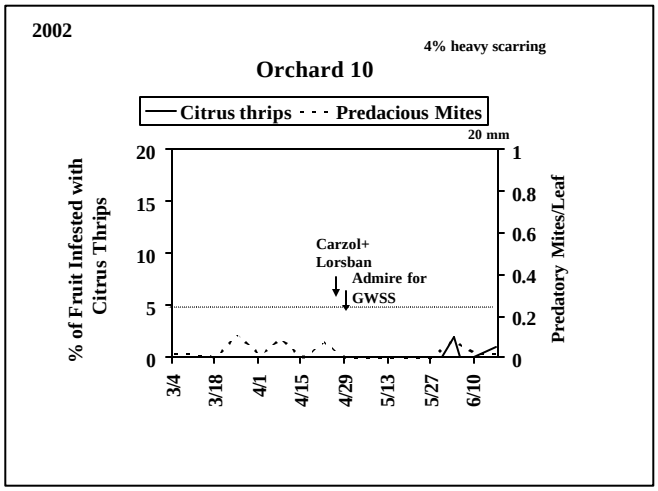


Figure 2. Trends in GWSS densities over 3 years of the program (2000-2002).

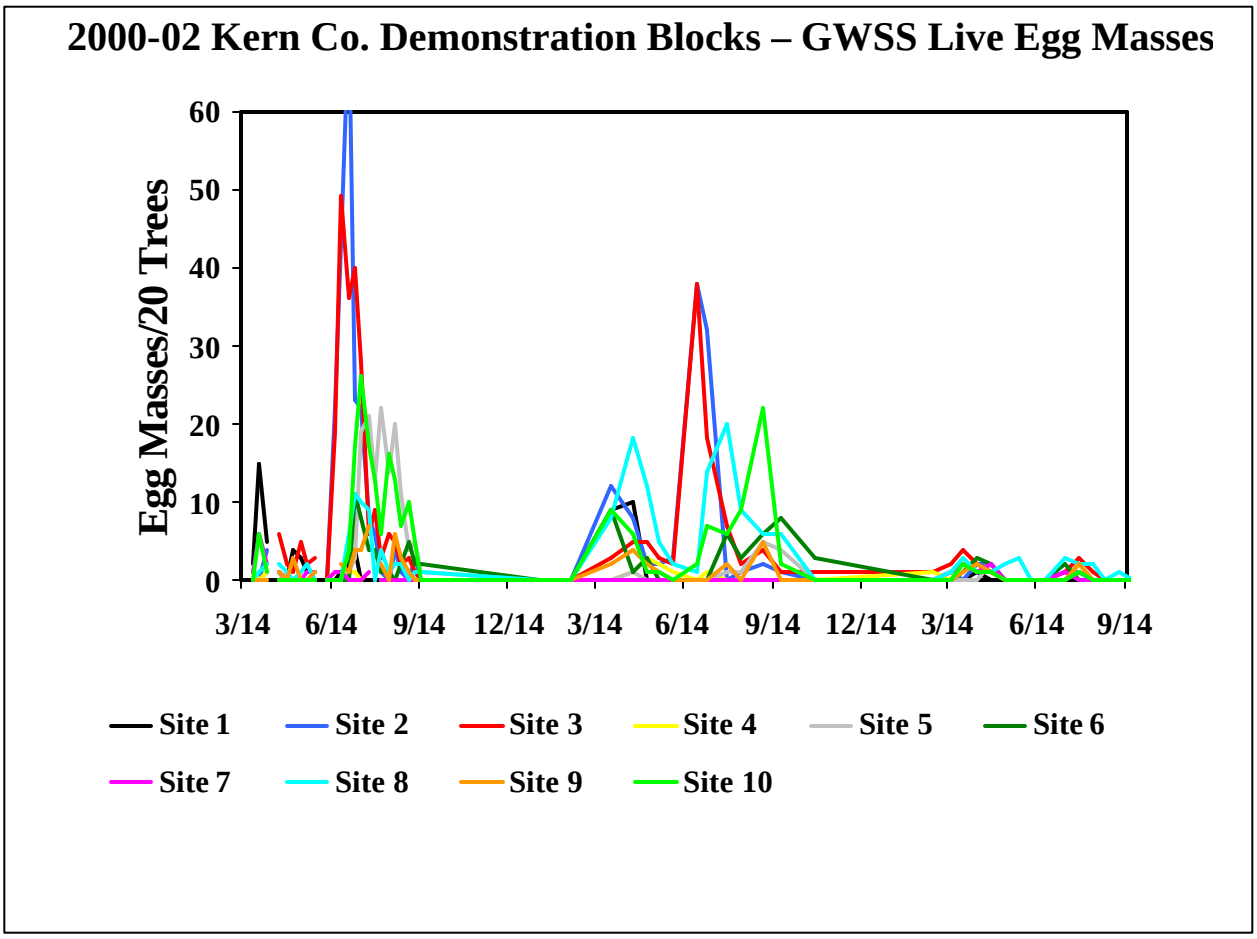
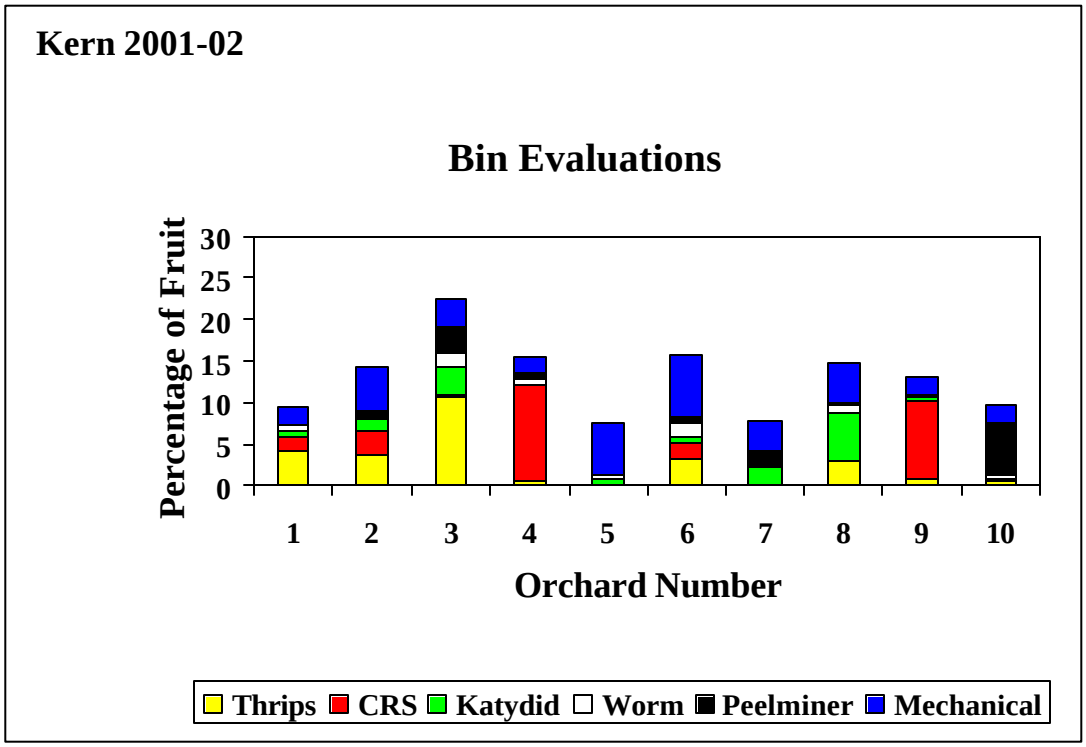


Figure 3. Fruit damage due to various arthropod pests (or mechanical damage due to wind scarring and equipment) in the Kern County Orchards.



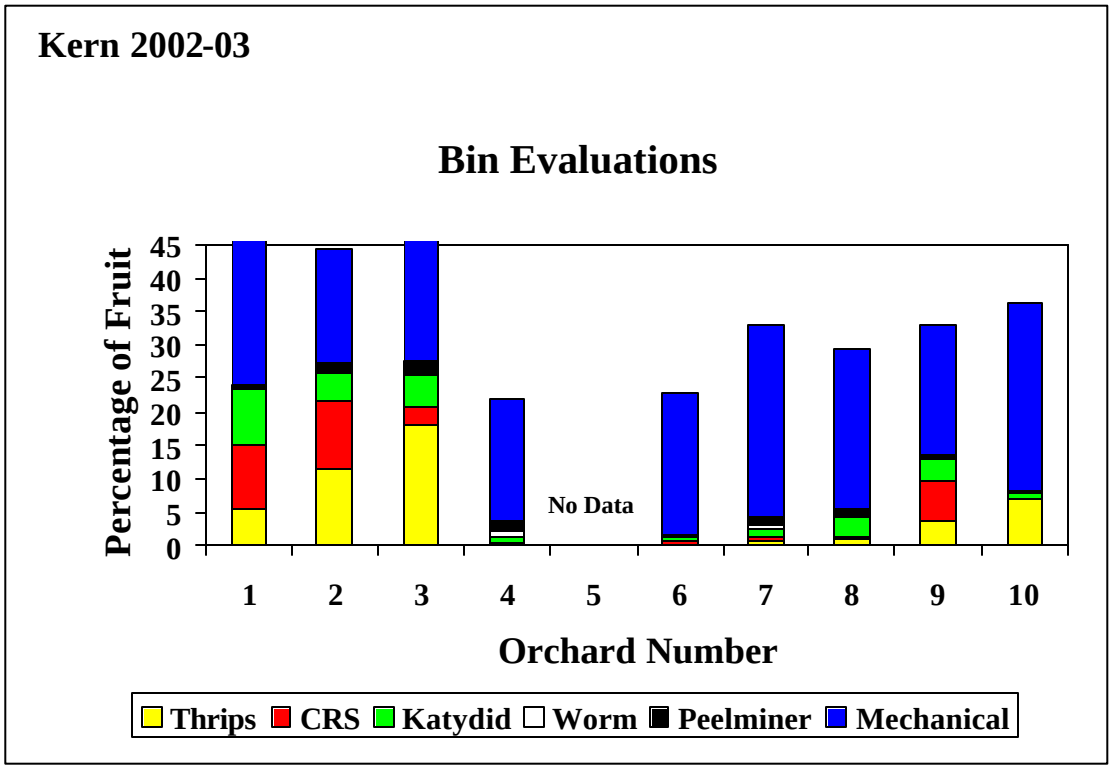
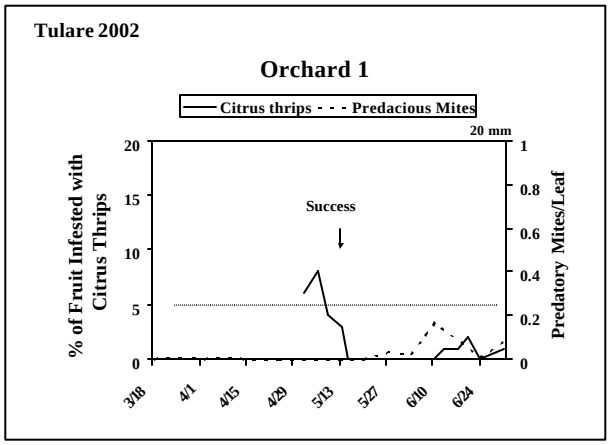
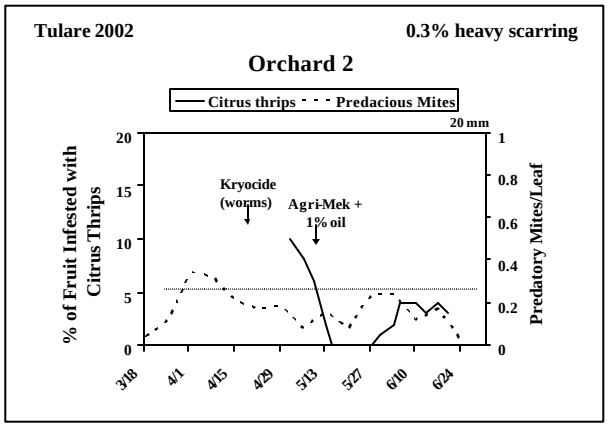
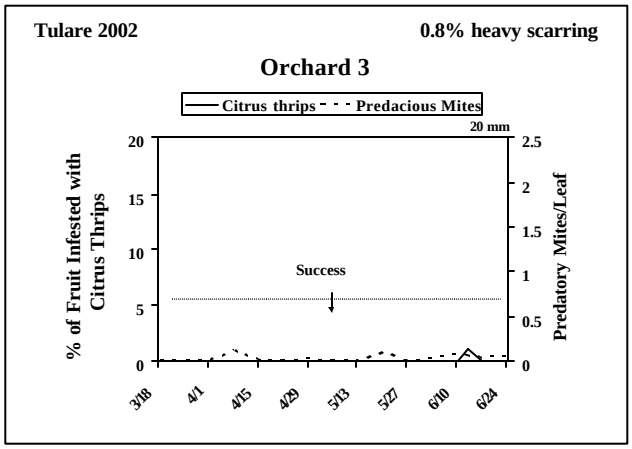
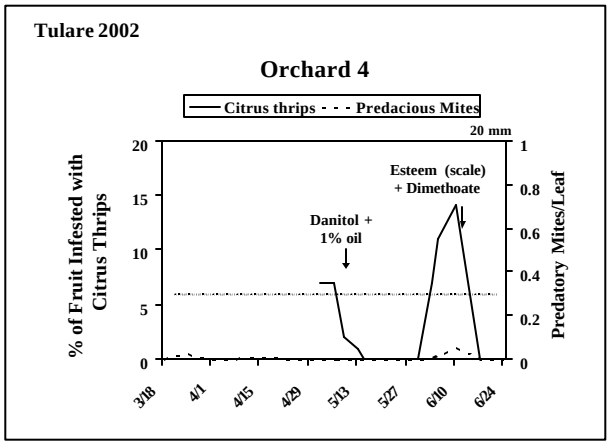


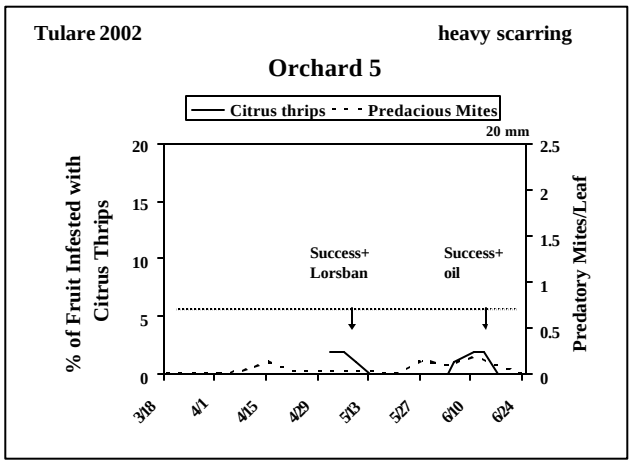
Figure 4. The impact of early season 2002 insecticide treatments for citrus thrips, katydid, and citrus red mite on pest densities and predacious mites in Tulare County.











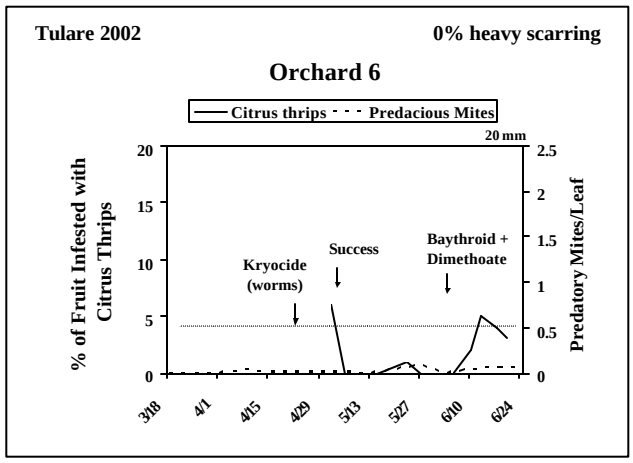
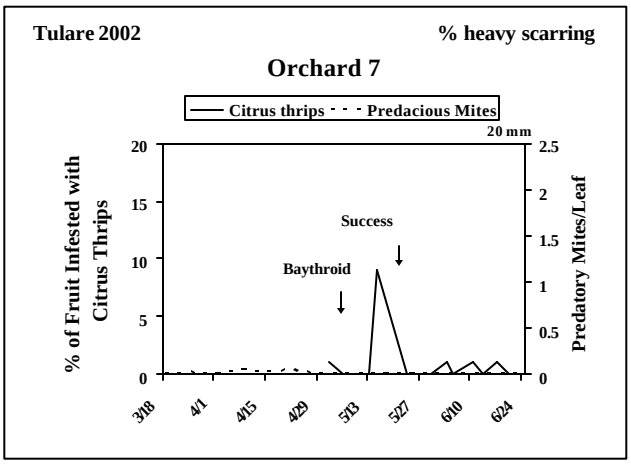
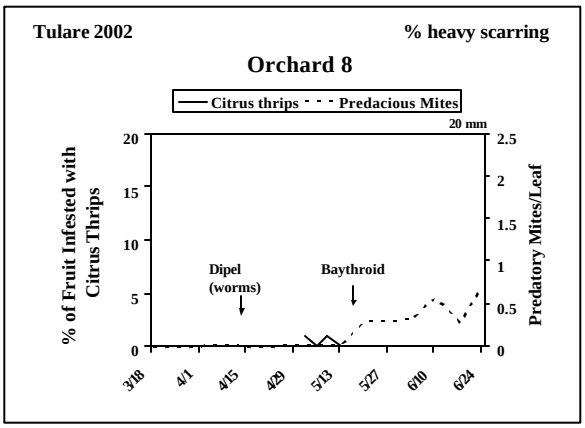
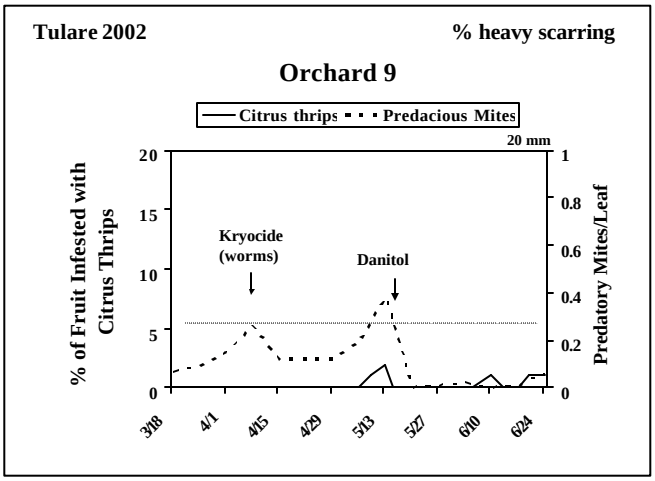


Figure 4. (continued). The impact of early season 2002 insecticide treatments for citrus thrips, katydid, and citrus red mite on pest densities and predacious mites in Tulare County.







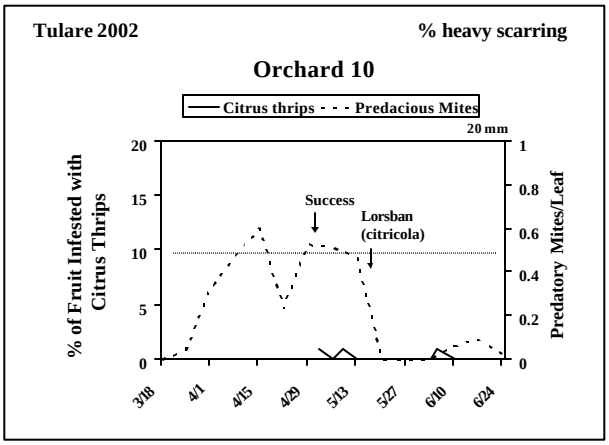
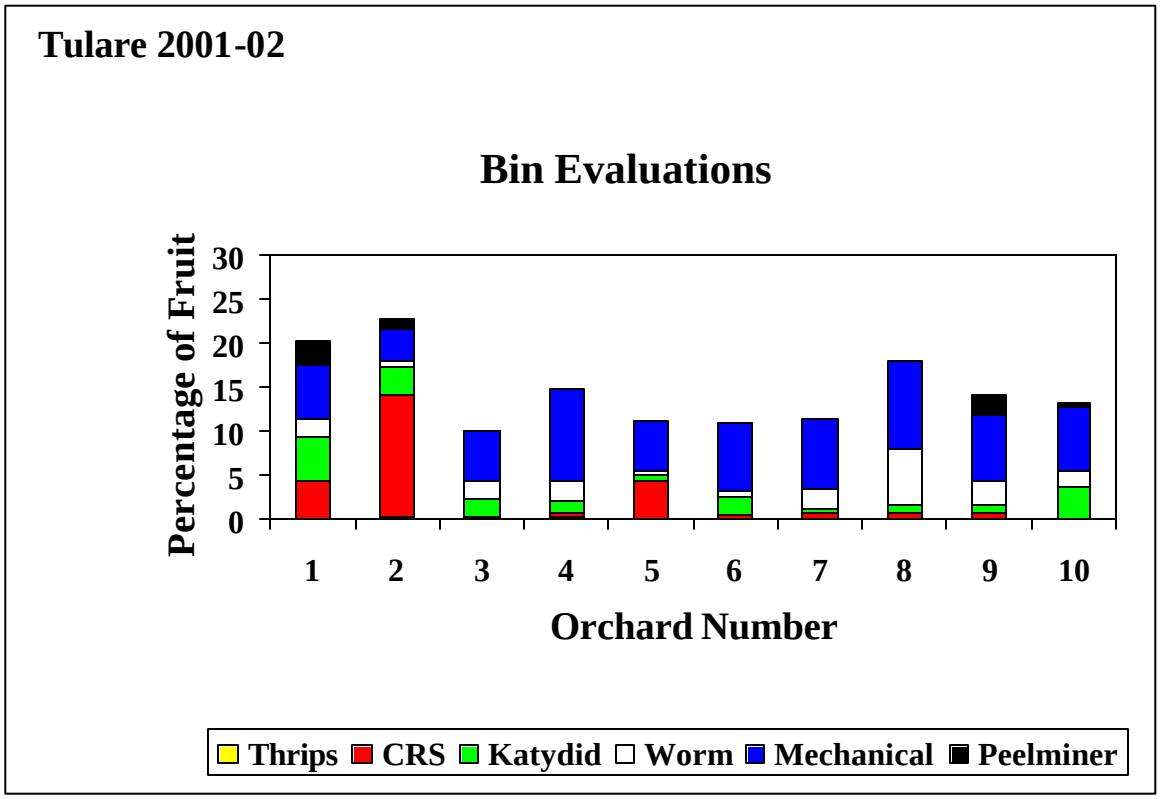


Figure 5. Fruit damage due to various arthropod pests (or mechanical damage due to wind scarring and equipment) in the Tulare County Orchards.



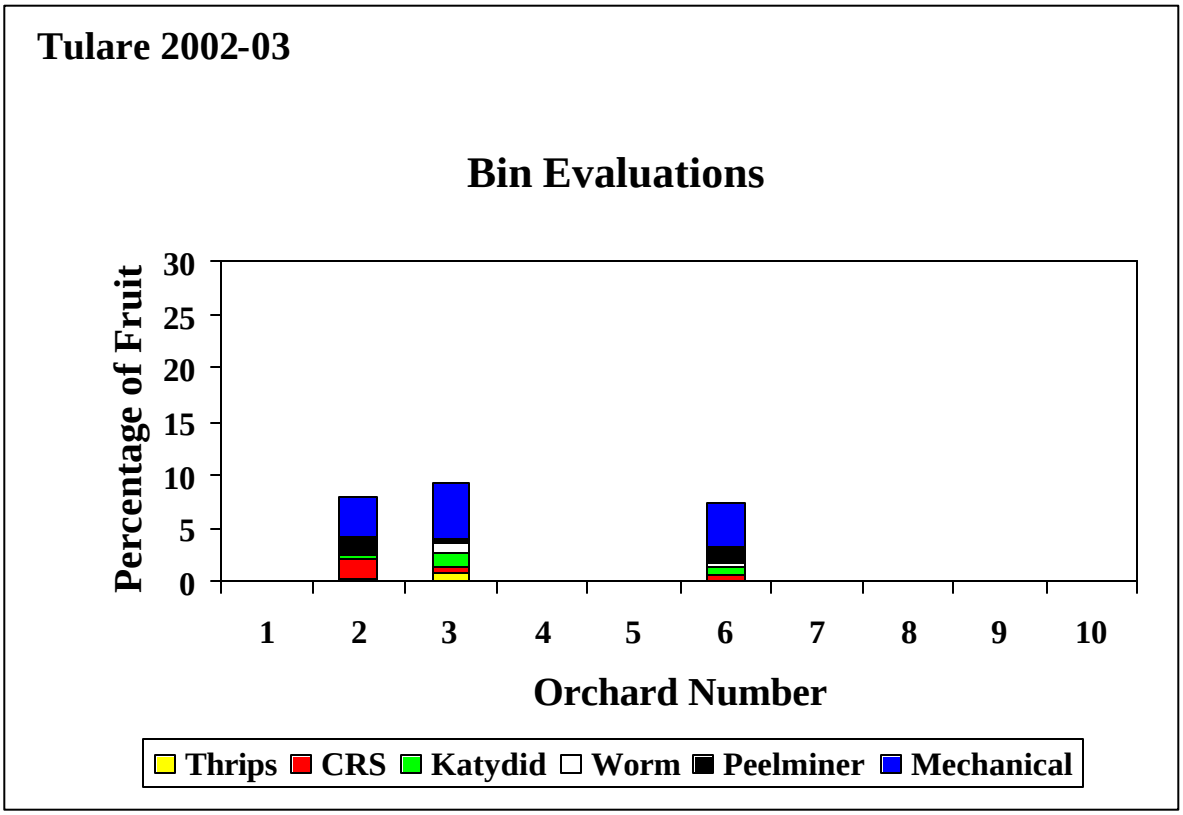


Table 1. Pesticide applications and *Aphytis* wasp releases conducted in the 10 Kern County orchards during 2001 and 2002. The grower in Orchard 1 is applying insecticides to aggressively reduce GWSS. Orchards 2-4 are releasing *Aphytis* wasps and conducting a biologically-based IPM program.

2001 - Kern

BL	Citrus Thrips/Katydid	CRS	Citricola	GWSS	Total	% Fancy Grade
1				Lannate x2 Admire	3	75% (Dec)
2	Success+.8% oil	Aphytis	Provado	Lannate	3 + Aphytis	76% (Nov)
3	Success +.7% oil	Aphytis		Lannate	2+ Aphytis	60% (Nov)
4	Veratran+Kryocide Success	Aphytis +Esteem		Admire Admire	5+ Aphytis	64% (Nov)
5	Success+Baythroid+oil				1	65% (Feb)
6	Success+Baythroid+oil Success +oil and Veratran	Esteem			4	42% (Feb)
7	Success+.8% oil			Admire	2	73% (Nov)
8	Agri-Mek+1.6%oil Cygon	Esteem		Evergreen	4	61% (Dec)
9	Baythroid+oil Baythroid/Success	Esteem			3	51% (Dec)
10	Danitol				1	77% (Nov)
Avg	1.4	0.4 +Aph	0.1	0.9	2.8 + Aph	

2002– Kern County

BL	Citrus Thrips/Katydid	CRS/Citricola	GWSS	Total	% Fancy Grade
1	Lannate		Admire	2	
2	Success+ oil	Aphytis Applaud+ oil	Admire	3 + Aphytis	
3	Veratran Success + oil	Aphytis	Admire	3+ Aphytis	65% *(Dec)
4	Veratran Kryocide	Aphytis	Evergreen Admire	4+ Aphytis	63% (Nov)
5	Success+Dimethoate+oil Success + oil		Admire	3	
6	Success+Dimethoate+oil Success + oil		Admire	3	
7	Success+Baythroid+oil		Admire	2	72% (Nov)
8	Success + Lorsban		Admire	2	82% (Dec)
9	Baythroid+oil	Esteem	Admire	3	59% (Jan)
10	Carzol + Lorsban		Admire	2	58% (Jan)
Avg	1.4	0.2 + Aph	1.1	2.7 + Aph	

*30% of the fruit is left on the tree

Table 2. Trends in thrips scarring and predacious mites in the presence of Lannate and Admire treatments applied for GWSS in Kern County.

Kern Treatments for Thrips & Katydids and % Thrips Damage (predatory mites) with Admire[A] or Lannate[L]

BL	2000	% thrips (predatory mites)	2001	% thrips (predatory mites)	2002	% thrips (predatory mites)
1	Veratran+sugar[A]	4.1 (high)	Lannate*	4.0[L] (low)	Lannate[A]	5.5 (low)
2 *Aphytis*	Success+.5% oil	6.7 (med)	Success+.8% oil	3.7[L] (high)	Success+ oil[A]	11.5 (low)
3 *Aphytis*	Success/Agri-Mek +.5% oil	0.1[L] (med)	Success +.7% oil	10.6[L] (low)	Veratran Success + oil[A]	18.0 (low)
4 *Aphytis*	Success[A]	0.0 (high)	Veratran+Kryocide[A] Success	0.6 (med)	Veratran Kryocide[A]	0.1 (high)
5	Success+1% oil	- (low)	Success+Baythroid+oil	0.0 (low)	Success+Dimethoate+oil Success + oil[A]	- (med)
6	Agri-Mek+1% oil Veratran+molasses	3.6 (low)	Success+Baythroid+oil Success +oil and Veratran	3.2 (low)	Success+Dimethoate+oil Success + oil[A]	- (med)
7	Success+.6% oil[A]	0.1 (high)	Success+.8% oil[A]	0.0 (med)	Success+Baythroid+oil[A]	0.6 (high)
8	Agri-Mek+ 1.6%oil[A]	0.1[L] (high)	Agri-Mek+1.6%oil Cygon	3.1 (med)	Success + Lorsban[A]	1.0 (high)
9	Baythroid+.5% oil	0.2[L] (high)	Baythroid+oil Baythroid/Success	0.8 (low)	Baythroid+oil[A]	3.7 (med)
10	Carzol+Lorsban	0.6 (low)	Danitol	0.5 (low)	Carzol + Lorsban[A]	7.0 (low)
Avg	1.1		1.5		1.4	

Table 3. Percentage of fruit infested with California red scale (% parasitism by *Aphytis* and *Comperiella* wasps) in Kern County orcahrds. Insecticide treatments for California red scale and glassy-winged sharpshooter and Aphytis releases for California red scale are shown.

2001 - Kern

% Fruit Infested with CRS (% parasitsm)

BL	July	Aug	Sep	Oct	CRS	GWSS
1	0	0	0	0		Lannate Admire
2	0	0	0	1	Aphytis	
3	0	0	3% (50%)	1	Aphytis	Lannate
4	13% (54%)	13% (66%)	14% (92%)	18% (89%)	Aphytis +Esteem	½ Admire ½ Admire
5	0	0	0	0		
6	0	0	0	0	Esteem	
7	0	0	0	0		Admire
8	0	0	0	0	Esteem	
9	0	7% (49%)	6% (73%)	5% (55%)	Esteem	
10	0	0	0	0		

2002 - Kern % Fruit Infested with CRS (% parasitsm)

BL	July	Aug	Sep	Oct	CRS	GWSS
1	9% (12%)	6% (34%)	20% (51%)	5% (36%)		Lannate Admire
2	19% (25%)	17% (31%)	6% (16%)	8% (27%)	Aphytis	Admire
3	3%	2%	4% (36%)	4% (33%)	Aphytis	Admire
4	2%	0	0	0	Aphytis	Evergreen Admire
5	0	0	0	0		Admire
6	0	0	2%	0	Lorsban	Admire
7	0	0	0	0		Admire
8	1%	0	0	0		Admire
9	4%	1%	2%	2%	Esteem (1/2)	Admire
10	1%	1%	1%	3%		Admire
					.2 + Aphytis	1.2

Table 4. Percentage of leaves infested with citricola scale during late 2001 and 2002 in Kern County. Insecticide treatments for California red scale and glassy-winged are shown.

2002- Kern % Leaves infested with citricola scale

BL	Sept 2001	2001 Trts	June	July	Sept	2002 Trts
1	0	Lannate Admire	1%	0	0	Lannate Admire
2	14%	Provado Lannate*	6%	17%	8%	Admire
3	75%	Lannate	4%	5%	2%	Admire
4	0	Admire Admire Esteem	0	1%	0	Admire
5	0		2%	0	0	Admire
6	0	Esteem	0	0	0	Admire Lorsban
7	0	Admire	1%	1%	0	Admire
8	0	Esteem	3%	3%	1%	Admire Esteem
9	0	Esteem	3%	4%	3%	Admire
10	0		1%	1%	0	Admire

Table 5. Pesticide applications and *Aphytis* wasp releases conducted in the 10 Tulare County orchards during 2001 and 2002. Orchards 1-3 are releasing *Aphytis* wasps and conducting a biologically-based IPM program.

2001 – Tulare County

BL	Citrus Red Mite	Citrus Thrips/Katydid	Ants	CRS/CCS	Total sprays	% Fancy grade
1		Lorsban (katydid)		Aphytis 1.2% 440 oil	2	51% (Mar)
2			Lorsban	Aphytis 1.2% 440 oil	2	59% (Apr)
3				Aphytis Esteem(border)	0	68% (Apr)
4		Baythroid		Lorsban	2	55% (Apr)
5	Vendex +0.5% oil	Success+ Lorsban+ 0.5% oil		Supracide + oil	3	61% (Dec)
6		Success Lorsban (katydid)		Lorsban + oil	3	63% (Nov)
7		Baythroid		Lorsban	1	39% (Nov)
8		Baythroid			1	-
9	Nexter	Success			2	54% (May)
10		Success + oil			1	68%
Avg	.2	.9	.1	.6 + Aph	1.8	

2002 – Tulare County

BL	Citrus Thrips/ Katydid	Worms	CRS	Citricola	Total sprays
1	Success		Aphytis		1+Aph
2	Agri-Mek+oil	Kryocide	Aphytis	Lorsban	2+Aph
3	Sucess		Aphytis		1+Aph
4	Danitol + oil		Esteem		2
5	Success+Lorsban Success		Esteem		3
6	Success Baythroid+Cygon	Kryocide	Esteem		4
7	Baythroid Success		Applaud		3
8	Baythroid	Dipel	Esteem		3
9	Danitol	Kryocide			2
10	Success			Lorsban x2	3
Avg	1.3	.4	.5 + Aph	0.3	2.5 + Aph

Table 6. Densities of cutworm larvae and response to the selective insecticides Kryocide and Dipel in Tulare County.

2002 – Tulare County

Number of cutworm larvae collected on beat sheets/20 trees

BL	Mar 11	Mar 18	Mar 25	Apr 1	Apr 8	Apr 15	Apr 22	Apr 29	May 6
1	0	0	0	1	0	0	0	-	-
2	0	0	0	0	0	0 Kryocide	0	-	-
3	1	0	0	2	0	1	0	-	-
4	1	9	15	17	26	24	1	2	0
5	0	4	0	0	1	3	0	-	-
6	4	2	13	16	13	4	4 Kryocide	2 Success	0
7	0	0	6	7	6	2	0	-	-
8	1	0	11	10	29 Dipel	11	6	0	-
9	2	1	7	15 Kryocide	5	5	0	-	-
10	0	0	3	5	3	1	0	-	-

Table 7. Percentage of fruit infested with California red scale (% parasitism by *Aphytis* and *Comperiella* wasps) in Tulare County. Insecticide treatments for California red scale and *Aphytis* releases are shown.

2001 - Tulare % Fruit Infested with CRS (% parasitism of 3rd instars)

BL	July	Aug	Sep	Oct	CRS	CCS
1	0	0	2%	3% (62%)	Aphytis 1.2% 440 oil	
2	0	11% (27%)	11% (39%)	18% (86%)	Aphytis 1.2% 440 oil	
3	0	0	15% (36%)	5%	Aphytis Esteem (border)	
4	0	0	1%	2%	Lorsban	
5	0	0	0	0		Supracide
6	0	0	0	0	Lorsban + 1% oil	
7	0	0	0	0		
8	0	0	0	0		
9	0	0	0	0		
10	0	0	0	0		
					Aphytis + .4	.1

2002 % Fruit Infested with CRS (% parasitism of 3rd instars)

BL	July	Aug	Sep	Oct	CRS
1	1	0	0	2%	Aphytis
2	8%	8% (35%)	6% (40%)	7% (50%)	Aphytis
3	1%	0	2%	2%	Aphytis
4	0	0	0	0	Esteem
5	1%	0	0	2%	Esteem
6	1%	0	1%	0	Esteem
7	0	0	0	0	Applaud
8	0	0	0	0	Esteem
9	1%	0	1%	3%	
10	0	0	0	0	
					Aphytis + .5

Table 8. Densities of citricola scale in the Tulare county orchards during 2001 and 2002 and their response to insecticides.

2001- Tulare Co. **Citricola scale nymphs/leaf**

BL	Thrips/Katydid	June	July	Aug	Sep	CRS/CCS
0	**Lorsban**	**0**	**0**	**0**	**0**	Aphytis **1.2% 440 oil**
2		**.05**	**0**	**.27**	**.20**	Aphytis **1.2% 440 oil**
3		**0**	**0**	**0**	**0**	Aphytis Esteem (border)
4	**Baythroid**	**0**	**0**	**0**	**0**	**Lorsban**
5	Success+**Lorsban** +oil	**0**	**0**	**0**	**0**	**Supracide** + oil
6	**Lorsban** Success	**0**	**0**	**0**	**0**	**Lorsban +** oil
7	**Baythroid**	**.03**	**0**	**.14**	**.02**	
8	**Baythroid**	**0**	**.13**	**0**	**0**	
9	Success	**0**	**0**	**0**	**0**	
10	Success + oil	**0**	**.13**	**.06**	**.06**	

2002- Tulare Co. **Citricola scale %infested leaves**

BL	June	July	Aug	Sep	CRS/Citricola
0	**0**	**1%**	**0**	**3%**	Aphytis
2	**36%**	**42%**	**56%**	**79%**	Aphytis Lorsban for citricola
3	**0**	**3%**	**1%**	**9%**	Aphytis
4	**0***	**0**	**1%**	**0**	**Esteem**
5	**0**	**1%***	**0**	**0**	**Esteem**
6	**0**	**0**	**0***	**0**	**Esteem**
7	**2%***	**0**	**0**	**1%**	**Applaud**
8	**0***	**0**	**0**	**0**	**Esteem**
9	**10%**	**1%**	**2%**	**2%**	
10	***0**	**20%**	**5%***	**0**	**Lorsban for citricola**

Table 9. Densities of cottony cushion scale in the Tulare county orchards during 2001 and 2002 and their response to insecticides.

2001- Tulare Co. **% Cottony cushion scale infested trees**

BL	Apr	May	Jun	Jul	Aug	Sep	CRS/CCS
1	50%	55% (V)	35% (V)	45%	8%	10%	Aphytis 1.2% 440 oil
2	0	0	0	0	0	5%	Aphytis 1.2% 440 oil
3	0	0	0	0	5%	5%	Aphytis Esteem (border)
4	0	0	0	0	0	0	Lorsban
5	25%	20% (V)	55% (V)	10%*	0	0	Supracide + oil
6	0	0	1	0	0	0	Lorsban + oil
7	0	0	0	0	20%	15%	
8	0	0	0	0	0	0	
9	0	0	0	0	0	0	
10	0	10%	0	0	0	0	

(V) = vedalia beetles present

2002- Tulare Co. **% Cottony cushion scale infested trees**

BL	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	CRS/CCS
1	55%	80%	(v)	8%	15%	28%	55%	60%	Aphytis
2	0	0	(v)	3%	0	3%	15%	10%	Aphytis
3	33%	35%	(v)	0	0	8	10%	10%	Aphytis Lorsban for citricola scale
4	0	3%	3%	0	0*	0	0	0	**Esteem**
5	0	0	0	0	0	3%*	0	0	**Esteem**
6	0	0	0	0	0	0	0*	0	**Esteem**
7	38%	23%	(v)	0	0*	3%	5%	5%	**Applaud**
8	0	0	0	0	0*	0	5%	0	**Esteem**
9	0	0	3	3% (v)	0	5%	0	10%	
10	0	0	0	0*	0	3%	0*	5%	**Lorsban for citricola**

(V) = vedalia beetles present

Table 10. Reduction in use of preemergent herbicides and resulting annual weeks

Orchard No.	Weeds/sq ft* Feb 2002	Weeds/sq ft June 2002	Weeds/sq ft August 2002
Post emergent herbicides only			
5	0.05	0	.026
10	0.05	0.11	.016
3	0.22	0.39	.037
9	0.64	0.03	.006
Pre and post emergent herbicide			
1	0.38	0.09	.042

*Ave./sq.ft.; sample two sq.ft winter, 170 sq.ft.summer.; 7-9/orchard

Table 11. Site 1: Weeds per sq foot in the NE and SW corners outside the canopy of the tree where the emitters were relocated or not relocated inside the canopy of the tree.

	NE corner of tree		SW corner of tree	
	Emitters Outside Canopy	Emitters Inside Canopy	Emitters Outside Canopy	Emitters Inside Canopy
June 2002 # weeds/sq.ft.	.42	.26	.85	.74
August 2002 #weeds/sq ft	.32	.06	.67	.13

Table 12. Site 2: Weeds per sq foot in the outside the canopy of the tree where the emitters were relocated or not relocated inside the canopy of the tree.

	Emitters Outside Canopy		Emitters Inside canopy	
	Row 1	Row 4	Row 2	Row 3
June 2002 # weeds/sq.ft.	1.99	1.15	0.87	0.54
Aug 2002 #weeds/sq ft	0.40	0.17	0.05	0.15

Table 13. Annual winter and summer weeds per sq. foot with and without a fall preemergent herbicide treatment.

	Fall 2001 Preemergent	Feb 2002 Weeds/sq ft	June 2002 Weeds/sq ft	August 2002 Weeds/sq ft
Site 1	Without	0	.2	.011
	With	0	.04	.001
Site 2	Without	18	.14	.030
	With	0.77	.06	.041